In this response, Applicants traverse the §102(b), §102(e) and §103(a) rejections, and respectfully request reconsideration of the present application in view of the following remarks.

Independent claims 1 and 11 stand rejected as being anticipated by Tekalp. Applicants note that each of independent claims 1 and 11 calls for a particular type of motion estimation based on a dense motion field of a portion of the image sequence. These claims each include limitations specifying substantially as follows:

(i) the estimate comprises a plurality of motion vectors each corresponding to an element of the dense motion field; and

(ii) the estimate is generated at least in part as a constrained function of a characterization of motion between elements of the dense motion field and elements of one or more other portions of the image sequence.

For reasons that will be described in greater detail below, Applicants respectfully submit that the Tekalp reference fails to teach or suggest at least the above-noted limitations (i) and (ii) of claims 1 and 11.

Applicants initially note that the importance of the claimed arrangement has been described in their specification at, for example, page 5, lines 5-18, as follows, with emphasis supplied:

> In conventional block-based video encoders, motion vectors are generally based on 16x16 or 8x8 blocks of pixels, since it has been determined that this amount of information can be coded in an efficient manner and sent to the decoder as side information. <u>Although finer motion vectors, e.g., motion vectors based on 4x4 or 2x2 blocks of pixels or on single pixels, provide better prediction, it has heretofore generally been believed that the resulting increased amount of side information cannot be encoded efficiently enough to produce an acceptable level of compression</u>.
>
> The present invention overcomes this problem by utilizing an MRF model which imposes a piecewise smoothness constraint on the motion field. This approach is appropriate since within a given object, it is expected that the motion will be uniform. By forcing the motion field to be smooth using the techniques of the invention, the motion field can be encoded very efficiently. <u>Without this smoothness constraint, i.e., if the dense motion field</u>

<u>estimation process simply attempted to find a motion vector for every pixel in the motion field by matching pixel data between frames, the resulting motion vectors would generally be going in many different directions and would therefore be very difficult to encode efficiently</u>.

The specification thus specifically points out that an unconstrained dense motion field estimation process, which attempts to find a motion vector for every pixel in the motion field by matching pixel data between frames, is problematic. The present invention as set forth in independent claims 1 and 11 overcomes this significant problem by generating the motion estimate "at least in part as a constrained function of a characterization of motion between elements of the dense motion field and elements of one or more other portions of the image sequence." It is this constrained function aspect of dense motion field estimation that is called for in limitation (ii) of claims 1 and 11.

The Examiner in rejecting independent claims 1 and 11 under §102(b) argues that the above-described limitations (i) and (ii) are disclosed by column 2, lines 45-50, and column 8, lines 1-17, respectively, of the Tekalp reference. Applicants respectfully disagree.

The column 2, lines 45-50 portion of the Tekalp reference relied upon by the Examiner as teaching limitation (i) of claims 1 and 11 states as follows:

> Another object of the invention is to provide a data compression system in which dense motion vectors are obtained representing values and directions of motion of the scene content between a temporally second image frame with respect to a temporally first image frame. The term "temporally" is not restricted to order of occurrence of the frames (dense motion estimation).

As indicated above, limitation (i) specifies that the estimate in the claimed invention "comprises a plurality of motion vectors each corresponding to an element of the dense motion field." Applicants submit that this particular limitation is not met by the above-cited portion of the Tekalp reference.

In addition, the column 8, lines 1-17 portion of the Tekalp reference relied upon by the Examiner as teaching limitation (ii) of claims 1 and 11 states as follows:

> For a new first image frame, first a motion segmentation algorithm is employed to determine the regions with different motions. Motion segmentation algorithms are known in the art, as for example, described in a publication by J.Y.A. Wang and E.H. Adelson, titled, "Representing moving images with layers," IEEE Trans. Image Proc., vol. 3, no. 5, September 1994, pp. 625-638.
>
> For each segment representing motions at least the following steps are taken:
>
> (a) Get the number of node points, mark all the pixels in the temporarily first frame which fall into the failure regions (BTBC), and fit a polygon around BTBC which determines the initial node points.
>
> (b) Using the dense motion field, compensate the temporarily second frame and find the displaced frame difference (DFD).

Applicants submit that this portion of the Tekalp reference fails to teach or suggest limitation (ii) of claims 1 and 11. As indicated above, limitation (ii) calls for a type of motion estimation in which the estimate "is generated at least in part as a constrained function of a characterization of motion between elements of the dense motion field and elements of one or more other portions of the image sequence." With regard to the above-cited passage from Tekalp, the Examiner states that the passage "clearly indicate[s] . . . that the estimation is done within a constrained area which is synonymous to a constrained function" (Office Action, page 2, first paragraph). Applicants respectfully disagree. The claimed "constrained function" is a constrained function <u>of a characterization of motion</u> between elements of the dense motion field and elements of one or more other portions of the image sequence. The claimed "constrained function" is therefore not synonymous with a constrained area based on image segmentation as taught by Tekalp.

It appears that Tekalp teaches to generate a dense motion field in a conventional manner (column 7, lines 6-13), and then to apply an image segmentation algorithm (column 8, lines 1-3) followed by a triangulation algorithm for each segment (column 8, lines 33-37) in order to obtain

a more efficient representation of the dense motion field. The above-cited portion of Tekalp from column 8, lines 1-17 refers to an exemplary segmentation algorithm, and fails to meet limitation (ii) as alleged by the Examiner.

Applicants therefore submit that independent claims 1 and 11 are not anticipated by the Tekalp reference. Dependent claims 2, 3, 12 and 13 are believed allowable for at least the reasons identified above with regard to their respective independent claims. Applicants respectfully request withdrawal of the §102(b) rejection.

Independent claims 21 and 24 stand rejected as being anticipated by O'Rourke. Applicants note that each of these claims calls for, in encoding an image sequence, generation of an estimate of apparent motion within the sequence, "wherein the estimate is generated at least in part utilizing a Markov random field (MRF) model to characterize motion between a given pixel of a motion field and one or more neighbor pixels." The Examiner argues that such an arrangement is disclosed in O'Rourke. Applicants respectfully disagree. The Examiner cites column 4, line 67 to column 6, line 60 of O'Rourke in conjunction with FIGS. 3A and FIG. 7 as providing the teachings (Office Action, pages 4 and 5). However, the reference to Huber Markov random field (HMRF) in the column 4, line 67 to column 5, line 36 portion of O'Rourke relates to <u>decoding</u> of a previously-encoded image sequence, and not to <u>encoding</u> of the image sequence as claimed. This is apparent from column 4, lines 53-58 of O'Rourke, which states as follows, with emphasis supplied:

> The <u>decompression</u> techniques implemented in the present invention will now be described in detail. To <u>decompress</u> the compressed image representation, a maximum a posteriori ("MAP") technique is used. The decompressed full resolution image is represented by z.

It is therefore clear that at least a portion of the cited passage relied on by the Examiner in formulating the §102(e) rejection relates to the use of the HMRF in a decoding process.

In addition, the reliance by the Examiner on FIG. 3A is misplaced. FIG. 3A shows "a block diagram of the encoder filter 300 used to calculate a sequence of step sizes," as indicated in column 5, lines 36-38. It fails to teach or suggest an encoder which generates an estimate of apparent motion

within a sequence "wherein the estimate is generated at least in part utilizing a Markov random field (MRF) model to characterize motion between a given pixel of a motion field and one or more neighbor pixels," as claimed.

Moreover, Applicants note that the motion estimation process implemented by FIG. 7 of O'Rourke is a type of conventional block-based motion estimation, such as that described by Applicants in the background portion of their specification. This is apparent from column 10, lines 7-62, wherein it is more particularly stated at lines 41-43 that "the motion estimator 755 generates a motion vector . . . for each block or macro-block of the current frame."

O'Rourke therefore teaches block-based motion estimation, and fails to teach or suggest the claimed generation of an estimate of apparent motion within an image sequence, "wherein the estimate is generated at least in part utilizing a Markov random field (MRF) model to characterize motion between a given pixel of a motion field and one or more neighbor pixels."

Applicants therefore respectfully submit that independent claims 21 and 24 are not anticipated by O'Rourke. Dependent claims 22, 23, 25 and 26 are believed allowable for at least the reasons identified above with regard to their respective independent claims. Applicants respectfully request the withdrawal of the §102(e) rejection.

With regard to the §103(a) rejection of dependent claims 4-8 and 14-18, Applicants initially note that each of these claims is believed to be allowable for at least the reasons identified above with regard to their respective independent claims.

Furthermore, with regard to claims 4 and 14, these claims relate to a characterization of motion in motion estimation of an encoding process. As indicated above, the reference to HMRF in O'Rourke relates to a decoding process. Applicants therefore submit that there is no motivation for the combination proposed by the Examiner. In other words, one skilled in the art would not be motivated to take an element of the decoding teachings of O'Rourke for use in the encoding process as claimed, particularly in view of the fact that O'Rourke itself fails to use the HMRF in its encoding process.

Similar arguments apply for at least dependent claim pairs 7, 17 and 8, 18. For example, the limitation regarding a MAP estimation problem with a constraint on entropy as set forth in claims 8 and 18 is not met by the use of MAP estimation in decoding as taught by O'Rourke. The Examiner

is taking decoding teachings from O'Rourke and arguing that they are readily combinable with the encoding process of Tekalp. However, there is no motivation identified for taking the O'Rourke teachings out of their decoding context in this manner. Applicants therefore believe that the §103(a) rejection is improper, at least to the extent it is based on decoding teachings from O'Rourke, and the rejection should be withdrawn.

In view of the foregoing, Applicants believe that claims 1-26 are in condition for allowance, and respectfully request the withdrawal of the §102(b), §102(e) and §103(a) rejections.

As indicated above, a Notice of Appeal is submitted concurrently herewith.

Respectfully submitted,

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